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A review on nuclear power plant scenario in Thailand

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ABSTRACT

Since early civilization, humans have required energy. Energy grows increasingly important with globalization. The search for energy sets nuclear power as the highest priority for generating electricity. The need to delay global warming initiated a nuclear power plant using a nuclear reactor as its source of thermal energy to generate pollution-free electrical currents. Many countries see the important advantages of nuclear power plants, and Thailand plans nuclear power plant projects (NPP) to be built by the Electricity Generating Authority of Thailand (EGAT). These projects have improved, and the latest Power Development Plan 2010–2030 (PDP 2010) states that by 2023, Thailand will build nuclear power plants with electrical productivity of about 4000 MW. The plants will generate commercial electricity for domestic consumption with plans to increase productivity in preparation for Thailand's economic growth and its participation in the ASEAN Economic Community (AEC). These efforts stem from investments in domestic and international industrial businesses in order to impress foreign countries with Thailand's energy security policy. However, the Thai people are concerned with the impacts of nuclear power plants. The people of Thailand require societal awareness in the construction of these plants.

Contents

1. Introduction

Based on the reports of the world primary energy consumption between 1985 and 2011 as shown in Fig. 1 [1], the considerable growth of electrical consumption in the world requires the massive use of nuclear energy. In 2010, demands for nuclear energy and renewable energy increased due to the limitations of fossil fuels such as oil, natural gas and coal [2–6]. As shown in Fig. 2 [7,8], a considerable portion of the electricity in the world in 2010 was generated from the fossil fuels-natural gas and coal-while nuclear energy supplied only 14 percent of the electricity demands [9].

World War II introduced the world to nuclear power. This power can be manipulated in order to solve high energy consumption with a growing world population and greater economic growth. Many countries, including Thailand, initiated the Nuclear Power Research and Development Institution with the expectation of making an effective use of this power in accordance with global warming reduction measures. Scientists have studied constructive purposes for nuclear reactions since 1951 [10]. A nuclear reactor generated electricity for the first time at the Idaho Engineering Laboratory in the United States [10]. Since then, several countries have shown increased interested in nuclear power for peace, including Thailand.

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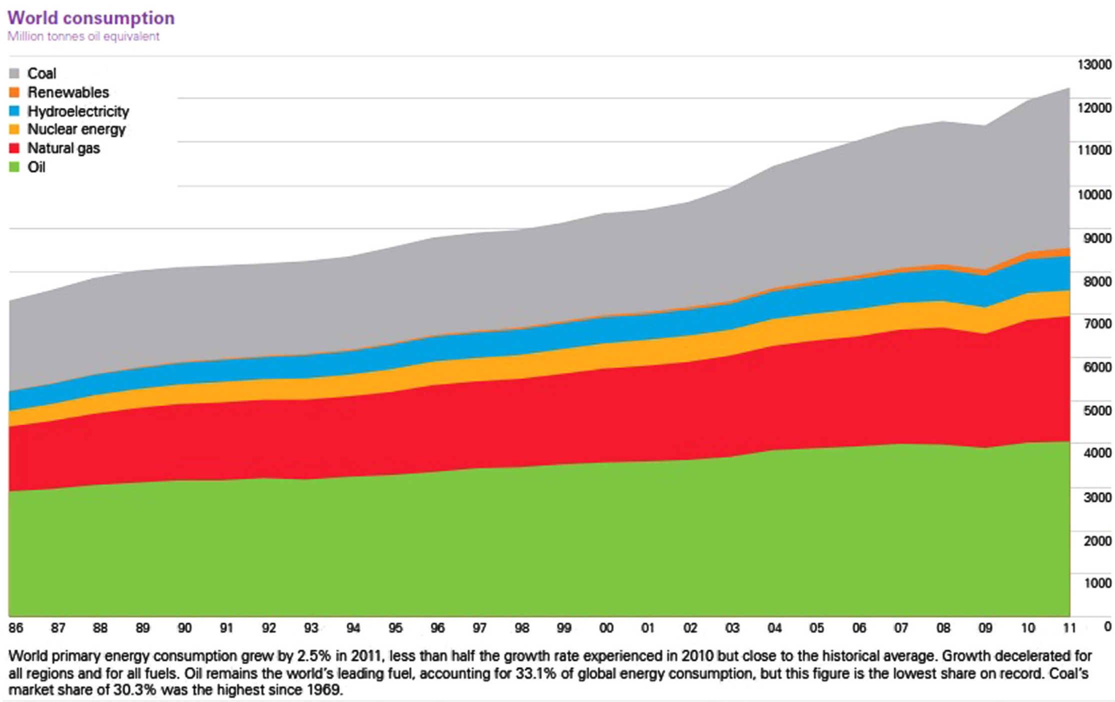


Fig. 1. World primary energy consumption 1985-2011 [from [1], with permission from BP].

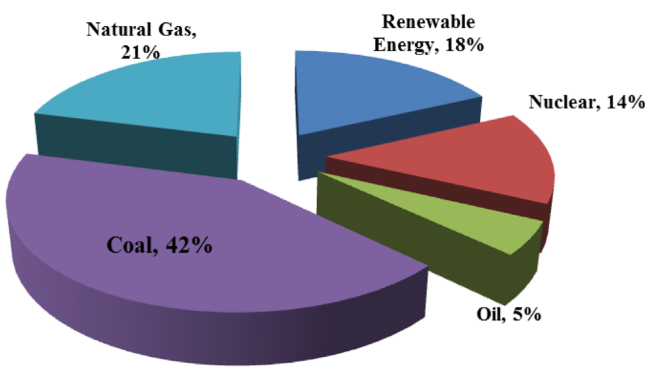


Fig. 2. World net electricity generation by energy source [data from [7,8]].

Thailand considers a plan to use nuclear power plants as an alternative source of energy. The Ministry of Energy of Thailand and its team of experts have devised and improved Thailand's Power Development Plan. Recently, the National Power Policy committee approved Thailand's Power Development Plan 2010–2030 (PDP 2010) with its strategies of creating confidence in the investment of electrical power development and reduction of greenhouse gas emissions from power plants in accordance with global warming measures [11]. The creation of secure energy reserves improved the strategy for electrical power production. For Thai people, energy is an important source that supports the country's development in agriculture, local economies, and public facilities. Energy must be cheap and adequate to meet demand.

Thailand plans for high energy consumption no less than 15 percent as the country continues to develop [11]. However, the retrieval of natural gas from the west coast may raise the increase in electrical production by more than 20 percent, according to Thailand's Energy Security hypothesis in the Power Development Plan 2010–2030 (PDP 2010). According to this plan, the addition of nuclear power plants to meet the increasing annual demand for electricity raises productivity rates 20 to 25 percent higher than actual demand. If additional power plants are not built, Thailand may encounter

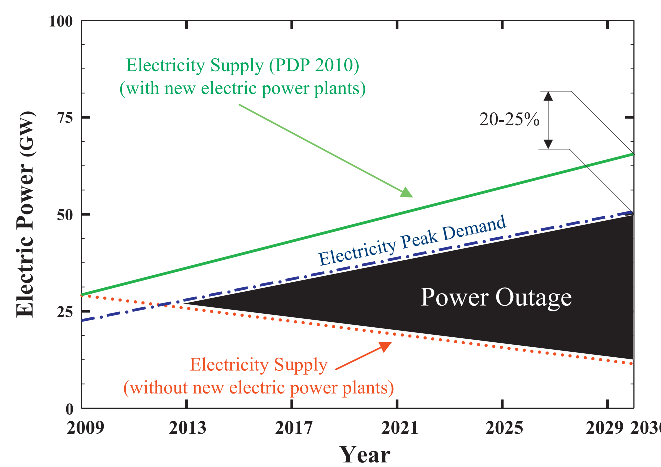


Fig. 3. Forecast of demand for electricity and electrical productivity of Thailand in 2010–2030 from PDP 2010 [data from [11]].

inadequate electricity beginning in 2013, which will negatively affect the public facilities and economy, as seen in Fig. 3.

With the implementation of an alternative energy development strategy, urgent strides are necessary to find sources of alternative energy. The generation of electricity from nuclear power plants with their lower-cost, greenhouse-gas-free clean energy and solid security should be an alternative in Thailand's national agenda. Advantages gained from nuclear power plants include: adequate electricity supply for future demand, a reduction of greenhouse gas emissions from carbon and natural gas power plants, and a reduction of dependence on natural gas, one-third of which is imported from Myanmar. All of these changes are significant for Thailand's energy security.

1.1. *Status and prospects of nuclear power plants in the world*

With the cost of fuel and the global warming directing the globe towards environmentally friendly alternative sources,

countries are choosing nuclear energy. Nuclear technology has progressed extensively in terms of work efficiency and safety. According to the report by the International Atomic Energy Agency (IAEA) in 2012 [12], the use of nuclear power plants is higher, particularly from 1954 to 1990. However, from 1990 to 2011, the number of nuclear power plants increased slightly, due to similar numbers for new and decommissioned nuclear power plants (Fig. 4(a)). In 2011, there were 435 nuclear power plants worldwide [12]. Examined by country (Fig. 4(b)), thirty countries had high numbers of nuclear power plants in 2011. With this rise in nuclear energy, countries compete in developing high-efficiency plants. When comparing the quantity of electricity output to the number of plants each year from 1954 to 2011 in terms of performance, current plants have a higher performance (Fig. 4(c)).

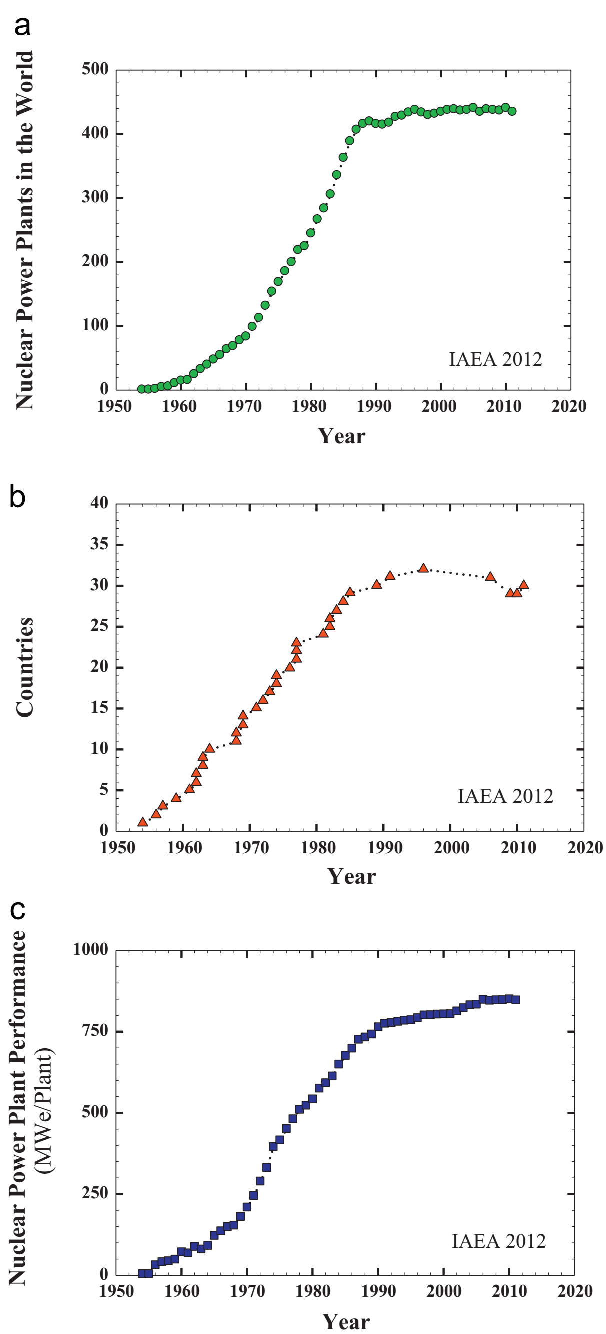


Fig. 4. From past to present (1954 to 2011) of (a) total number of nuclear power plants in the world, (b) number of countries with nuclear power plants, (c) average performance of nuclear power plants in the world [data from [12]].

The most widely used nuclear power plant is the pressurized-water reactor (PWR) [12]. The circuit-heat ventilating substance is highly controlled, so water has a higher temperature level than its boiling point without vaporization. The fast breeder reactor (FBR) can generate approximately 50 times more energy than the existing thermal reactors. Besides energy, this type of reactor, already used in China and Russia, can produce more plutonium fuel than the fuel breeder without a neutron moderator. This analysis clearly shows that nuclear power plants tend to have higher performance. However, Fig. 4(c) shows that the nuclear power plant performance from 2005 to 2011 remained constant or changed slightly due to various countries using lower performance. When compared with the number of all nuclear power plants worldwide, the electrical production scale in the future will increase, due to the improved performance of new nuclear power plants.

The International Atomic Energy Agency's meeting (IAEA) in 2012 shows that France has the highest rate of electrical production from nuclear power plants, 77.7 percent of total production [12]. The United States has the highest number of nuclear production plants, 104 with one reactor under construction. Asia, shown in Fig. 5 [12,13], has comparable numbers with: Japan's 50 plants including two under construction and 10 reactors planned, South Korea with 21 plants including five under construction and two planned, India with 20 plants including seven under construction, China with 16 plants including 26 under construction and 42 reactors planned, Pakistan with three plants including two under construction, Iran with one plant including three planned, and Armenia with one plant.

In the Association of Southeast Asian Nations (ASEAN), Vietnam has planned the construction of two nuclear power plants in the Ninh Thuan Province. Vietnam plans to construct the first plant in the Vinh Truong Village, Phuoc Dinh estate, and the second in the Thai An Village, Vinh Hai estate. Both plants will produce 4000 MW. Russia will provide support in budget, construction, staff preparation, security measures, and R&D in nuclear use for peace. The closest nuclear power plant accessible to Thailand is in Vietnam. Within six years, if the plan succeeds, Vietnam will be the first ASEAN country that will use nuclear power plants [14].

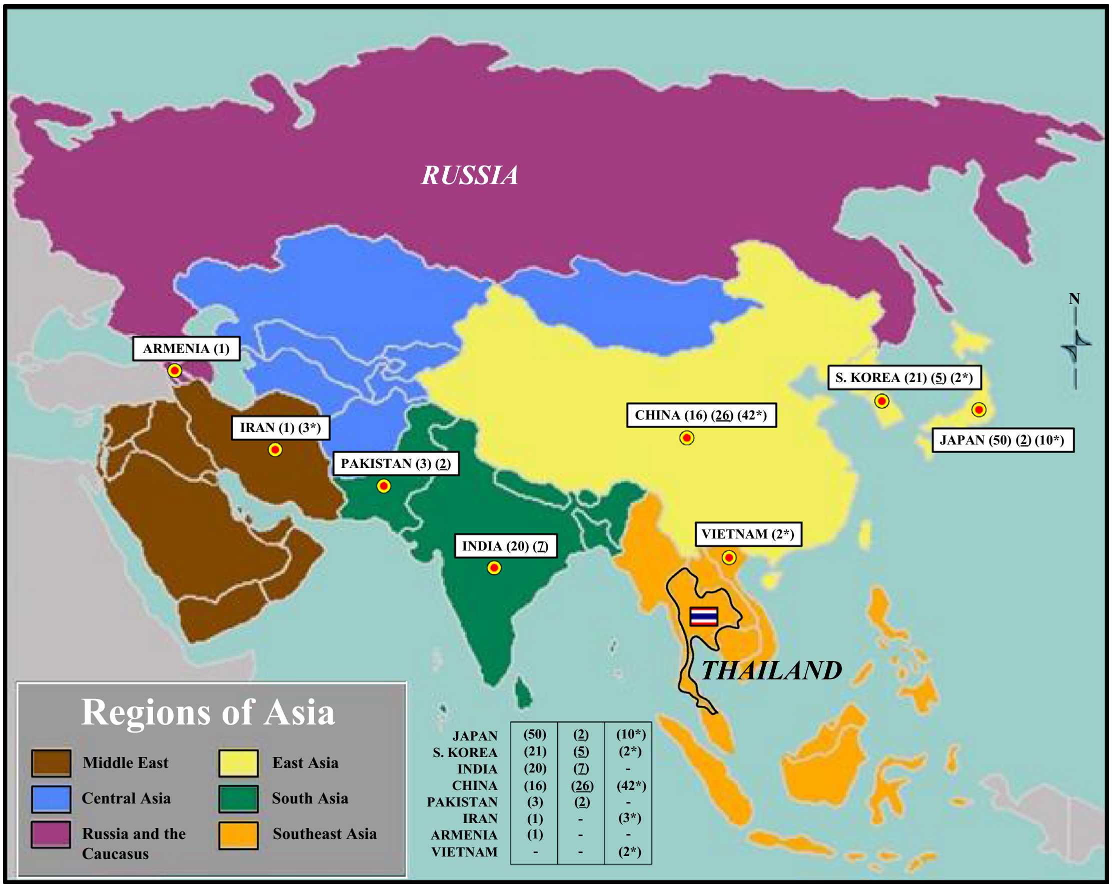
Neighboring countries to Thailand not on the list of the International Atomic Energy Agency (IAEA) but who might develop nuclear-powered electric power plant projects are detailed in the following paragraphs [15–20].

In the 30th ASEAN Ministers of Energy Meeting (AMEM) in September 2012, the government of Cambodia expressed an interest in launching a nuclear-powered electric power plant in Koh Kong province, which is closed to the border of Thailand. Their related agencies were assigned to study, and foreign experts were hired to conduct a feasibility study [15]. This study prepared for the economic expansion of the country's fuel use with higher cost of production. However, in October of the same year, Cambodia announced that it was not ready to construct the planned nuclear-powered electric power plant [16].

With the need for electricity in Indonesia, its government initiated several electric plant development projects. Additionally, it proceeded with the construction of nuclear-powered electric plants on Bangka Island, located on the southern coast of Sumatra Island, which had earthquakes due to volcano fault lines [17,18]. The nuclear-powered electric plants would be able to operate with a capacity of 6 GWe in 2025 [18].

Malaysia is concerned about the safety and danger of nuclear-powered electric plants postponing the planned launch of the first and second 2 GW-capacity nuclear-powered plants expected to operate in 2021 and 2022, respectively [19].

Myanmar's army announced its plan to develop peaceful nuclear projects, such as nuclear energy in cancer treatment. The



Notes :
X = Number
(X) = Reactors in Operation,
(X) = Reactors under Construction,
(X*) = Reactors Planned for Construction”

Fig. 5. Asian countries with building-in-progress nuclear power plants and future plans for nuclear power plants [data from [12] and map of Asia from [13]].

army did not consider nuclear development in creating a lethal weapon. The army will study nuclear energy for societal prosperity according to international standards, such as nuclear energy for medical use, energy, and the country's scientific development [20].

Many countries did not announce any policies in the construction of nuclear-powered electric plants, but these countries will learn of the importance of these projects and follow suit.

1.2. Nuclear power plant potential in Thailand

A modern lifestyle using science and technology requires an extensive amount of energy. Consequently, energy consumption rises, and countries such as Thailand depend on the help of outside sources for energy. Alternative energy sources help in reducing the amount of imported fuel. One energy source that scientists and academics see as having an important role in replacing oil, coal, and natural gas is nuclear power via nuclear power plants. The 7th National Economic and Social Development Plan (1992–1996) requested a feasibility study for nuclear power use in generating electricity in the economy, technology, and safety [21], as well as improving public relations.

Nuclear power plants in Thailand present two problems. First, energy is scarce. The supplies of fuel, natural gas, and coal are inadequate for the newly built power plants. Thailand depends on imported fuels from other countries. Thailand's electrical generation is increasingly tied to natural gas and coal imports.

The use of coal power plants in Thailand leads to high emissions of poisonous gases, CO_2, SO_X, and NO_X, into the atmosphere. These emissions cause air pollution, acid rain, and greenhouse gas. A nuclear power plant does not produce any of these gases. Nuclear power has less residual-spent fuel, which can remain in a plant for thirty years without any environmental problems.

Thailand's Power Development Plan utilizes nuclear power in order to reduce the dependency on fuels such as natural gas requiring imports from other countries for electric generation. In order to achieve security in electric generation, Thailand should retain at least 20 percent of reserved productivity due to the risk of finding natural gas supplies. With environment conservation through reduction in greenhouse gas emissions from new power plants and reserved productivity, Thailand exemplifies its Power Development Plan 2010–2030 (PDP 2010). High demand for household electricity and industrial growth requires the construction of more power plants. Diversity in electric generation would lower the dependency on natural gas and allow for successful electrical imports.

According to the Thailand Energy Statistics 2011 reported by the Ministry of Energy [22], as shown Fig. 6, Thailand depends on natural gas for 67.7 percent of its energy needs, compared to other fuels. Fig. 7 shows electricity by type of fuel in the PDP for 2010.

From 2015 to 2030, natural gas usage for electric generation declines while electric generation from nuclear power increases to 11 percent of total productivity in 2030. This strategic plan addresses the importance of using diversified types of fuels for electric generation. As a result, this generation requires five 1000-MW nuclear power plants [11]. Currently, the Power Development Plan 2010–2030 (PDP2010) is being revised to postpone the installation of four 1000-MW nuclear power plants, with a total productivity of 4000 MW [23].

This scientific reasoning, nuclear power plant licensing, site selection, plant construction, staff preparation, and management of radioactive waste to prevent radioactive leakage, and approximately ten years in advance full operation will lead Thailand to continue its construction in nuclear power plants. The plan for nuclear power plants in Thailand is shown in Table 1. The five technically viable sites are [24]: (1) Tha Tako District, Nakhon Sawan Province; (2) Sirindhorn District, Ubon Ratchathani Province; (3) Khlong Yai District, Trat Province; (4) Lamae District, Chumphon Province; and (5) Tha Chana District, Suratthani Province (Fig. 8). Selection of a technically viable site consists of four phases, and Thailand is in the third phase, the identification of candidate sites.

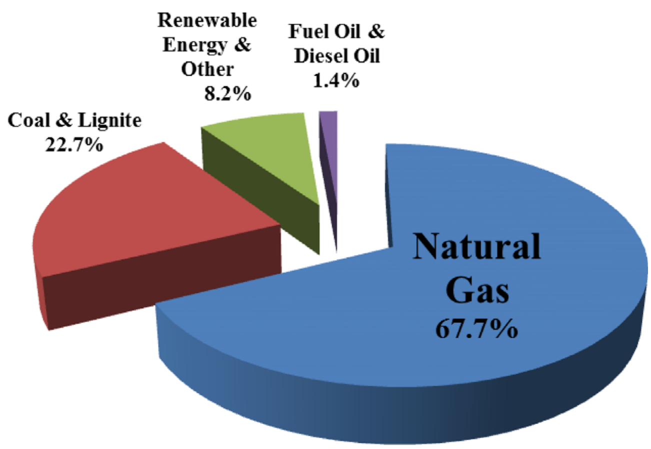


Fig. 6. Ratio of fuel used for generating electricity in Thailand in 2011 [data from [22]].

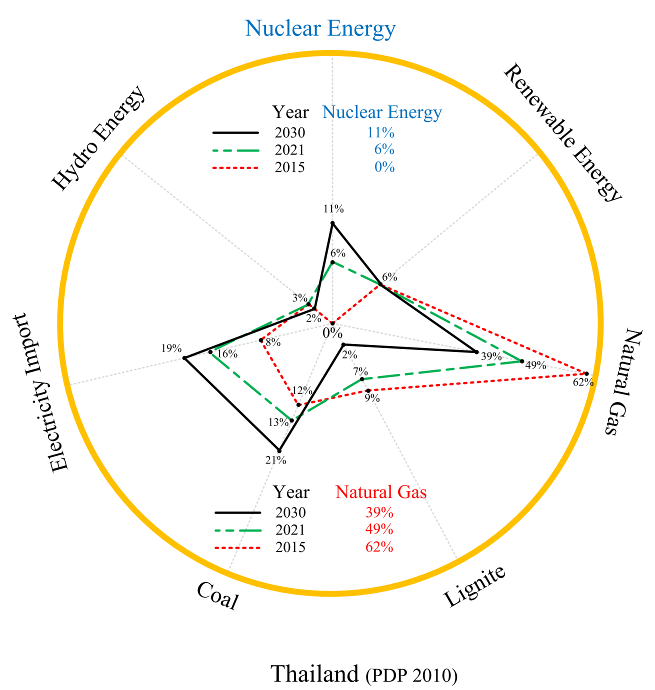


Fig. 7. Proportion of electrical power by types of fuel in the electrical Power Development Plan of Thailand for 2010–2030 [data from [11]].

1.3. History and background of nuclear energy in Thailand

The nuclear power plant officially began in Thailand with the founding of the Office of Atoms for Peace (OAP) [25]. According to the Atoms for Peace Act of 1960, the mission of the OAP is the issuance of policies, guidelines, and strategies in order to monitor and ensure the safety of the concerned parties according to international guidelines and standards [25]. The office has an obligation to support economic and social development through the safe utilization of nuclear power.

Thailand utilizes nuclear energy in medicine, agriculture, material industries, and power plant construction plans. The Nuclear Power Project (NPP) is important [26]. This project began when the Electricity Generating Authority of Thailand (EGAT) proposed the construction of nuclear power plants to a permissive government in 1966.

- In 1967, the government appointed the Nuclear Sub-Committee to consider the suitability of the NPP and to select sites.
- In 1969, the government approved sites selected for the construction of a nuclear power plant at Ban Aow Phai Subdistrict, Sri Racha District, and Chonburi Province.
- In 1970, the International Atomic Energy Agency (IAEA) approved the sites selected for nuclear power plant construction in Thailand.
- In 1972, the government gave its approval for 600-MWe boiling water reactor (BWR) in the Ban Aow Phai Subdistrict, Sri Racha District, and Chonburi Province.
- In 1974, Energy Research and Development Administration (ERDA) reserved uranium fuel in the United States.
- In 1976, a bid for nuclear power plant construction was submitted for approval with a scheduled operation in 1985.
- In 1978, the Thai government postponed the NPP projects indefinitely because it found a source of natural gas in the Thai Gulf in 1977.
- From 1982 to 1995, the Electricity Generating Authority of Thailand surveyed and studied various sites for the construction of nuclear power plants.
- In 1996–1998, the government permitted a committee appointed by the Ministry of Science and Technology to conduct a feasibility study for constructing nuclear power plants in Thailand, with a purpose to solve economic and infrastructure issues.
- In 1997, an economic crisis hit Thailand.
- In 2006, the Electricity Generating Authority of Thailand began to consider the nuclear power plan.
- In 2007, the National Energy Policy Commission (NEPC) gave its approval for the Power Development Plan 2007–2021 (PDP2007), which includes a plan for nuclear power use from two 1000-MW nuclear power plants in 2020 and two more plants in 2021.
- In 2008, the commission coordinated preparations for the construction of nuclear power infrastructure and selected the Burns and Roe Asia, Company Ltd. (B&R) as the consultant for the feasibility study of nuclear power plants. The committee of the Electricity Generating Authority of Thailand hired Burns and Roe and issued a Letter of Intent.
- In 2009, the Power Development Plan 2007–2021 (PDP2007^{rev}) was improved to reduce the electricity productivity of nuclear power plants to 1000 MW per year between 2020 and 2021.
- In 2010, the National Energy Policy Commission (NEPC) approved the Power Development Plan 2010–2020 (PDP2010) including a 5000-MW nuclear power plant starting in 2020.

Table 1
Nuclear power plant planning (Milestones for Nuclear Power Utility Planning, NPP).

Phase of project	Duration of project	Activities
Phase 0.1 Preliminary Phase	2007 (1 year)	– Placing project in Power Development Plan (PDP) – Appointing a committee to study suitability of electric generation in order to consider important issues and the procedure of the project – Prepare a Nuclear Power Infrastructure Establishment Plan (NPIEP)
Phase 1 Pre-Project Activity Phase	2008–2010 (3 years)	– Survey potential sites for plant construction – Conduct a feasibility study of the project and create understanding with public participation
Phase 2 Program Implementation Phase	2011–2013 (3 years)	– Set up an organization to monitor the project – Conduct a feasibility study of the project and create understanding with public participation – Enforcement of law and international obligations – Select suitable sites for plant construction, as well as appropriate technology and constructor, and start bidding
Phase 3 Construction Phase	2014–2019 (6 years)	– Complete the bidding process – Design and bid of engineering work – Construct and install equipment – Conduct system tests and inspection – Apply for permission to start the operation of the plant
Phase 4 Operation Phase	Start at 2023	– Start operation for commercial – Operate and maintain the plant – Plan for future increase of productivity – Plan for related industrial and technological development

- In 2011, the National Energy Policy Commission (NEPC) permitted the adjustment of the Power Development Plan 2010–2030 (PDP2010^{rev}) to defer the schedule of the 4000-MW nuclear power plant by three years. This decision came from concerns with a nuclear power plant accident after the earthquake and tsunami in Fukushima, Japan. The event was a natural disaster with no reactor malfunctions or human error. However, this incident led to its reconsideration and deferral of the project until 2023.

The MPP project needs to take the results from a survey of public opinion into consideration concerning the construction of nuclear power plants [27]. 3807 people, ages eighteen through sixty, were surveyed in various provinces, including Bangkok. The ABAC Poll Research Institute, a highly regarded research organization in Thailand, conducted the survey. Results of the survey indicate that about 83.4 percent of people do not agree with the plan for constructing nuclear power plants in Thailand. Only 16.6 percent agree with the project [27]. This evidence proves that, despite the many advantages of nuclear power plants, people still worry about nuclear explosions. In addition, people are concerned with radioactive waste management or spent fuel. Environmental agencies should boost the public's confidence in safety. Thailand fortunately has multiple organizations and has produced engineers with the knowledge and capability in controlling the operations of nuclear power plants, which could help increase public confidence. Furthermore, there are globally approved organizations such as the (International Atomic Energy Agency [IAEA]) to oversee operations and promote international cooperation concerning the use of nuclear energy for peace. Laboratories and research centers are promoting the construction of nuclear power plants in countries. For example, the Sandia National Research Institute in the United States provides strength tests for reactor-building wall. These tests examine their resistance for collision and unplanned accidents. Similar efforts would increase the confidence among Thai people surrounding nuclear power plants.

Over the years, the Electricity Generating Authority of Thailand (EGAT) has prepared potential sites, surveyed locations, conducted geological inspection, prepared water resource for use in the nuclear plants, and found suitable areas for the construction of the nuclear-powered electric plants [24]. However, there is resistance from local communities. People ask for a public hearing to discuss pros and cons, particularly, the safety promised in case of an accident similar to the nuclear plant in Japan. However, when nuclear-powered plants are compared with electric power plants, it is found that nuclear-powered plants have lower cost of fuel and are a reliable source of electric production. Due to its ability to run continuously for two years without closing, the plant has a lower cost of electric production and emits less carbon dioxide. Therefore, the nuclear-powered plant project (NPP) is a sufficient solution for Thailand in solving the energy crisis. However, the first nuclear power plant of Thailand should be a small plant of 100-200 MW capacity, which will take at least 10 years for preparation and operation. The large-scale one with 1000 MW capacity will require up to 20 years for preparation and operation [28].

2. Conclusion

This paper provides an overview of a plan to use nuclear power plants as an alternative source of energy in Thailand. This analysis assesses successful plans to promote nuclear energy within the country.

The Thai government deferred the nuclear power plant construction plan of the Electricity Generating Authority of Thailand (EGAT) in order to study public opinion concerning natural disasters and their effects. The Thai people are worried about the dangers of nuclear power plants. Education about nuclear power plants is very important. Public relation campaigns and community involvement in the nuclear power plant construction projects will help reduce these concerns and increase the country's confidence.

To ensure energy security, Thailand should construct nuclear power plants that, in economic aspects, have the lowest unit cost.

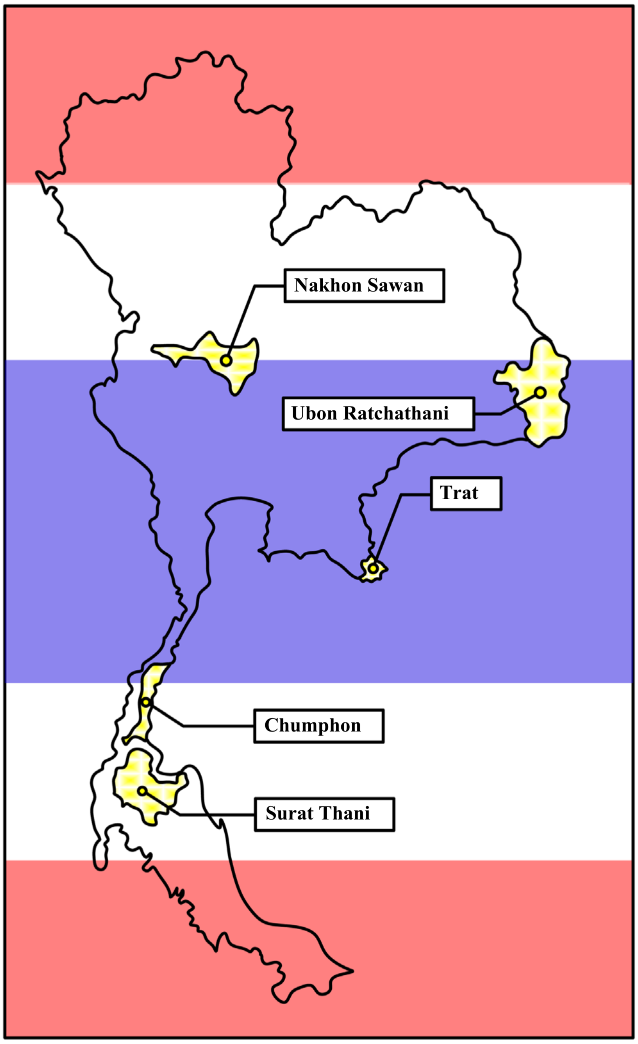


Fig. 8. Suitable locations for nuclear power plants in Thailand [data from [24]].

Thailand should pressure large-scale nuclear power plants to be cost-effective. Since Thailand is a developing country, increased needs of domestic and foreign investors require great demand.

Thailand should have nuclear power plants in order to prepare for secure energy consumption. Thailand will be prepared with energy policies with the Asean Economic Community, which will affect business and society in Thailand in the near future. However, Thailand should maintain secure areas near nuclear power plants for community and global safety.

Acknowledgements

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